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A STUDY OF FELDSPAR CRYSTALS FROM NORWAY, MAINE[1]

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INTRODUCTION

This paper is the result of an investigation of the crystallographic properties of some feldspar crystals obtained by Dr. Palache in the summer of 1913 from pegmatite veins at Horse Hill, Norway, Maine, and now in the mineralogical collection of Harvard University. The measurement, projection and drawing of the crystals was done in the Crystallographic Laboratory at Harvard, while the optical work was carried out in the Geological Laboratories, of the Massachusetts Institute of Technology.

THE GRANITE

The following description of the granite in which the pegmatite veins occur is made from specimens adhering to the walls of the veins, and owing to its proximity to the pegmatite, this may be somewhat different from the ordinary granite of the region.

The granite is very light grey, almost white, speckled with shiny black biotite crystals, has a medium to fine even grain, and presents a slightly crushed appearance. About 75 percent of the rock is a chalky white, rarely glassy feldspar; about 15 percent is biotite, and about 10 percent dull grey quartz. Irregularly scattered through the rock, especially adjacent to the pegmatite veins are euhedral grains of muscovite, up to three-fourths of an inch across, but averaging three-eighths of an inch, and usually one-fourth of an inch thick. Muscovite of the ordinary size of grain of the rock is also a constituent.

In thin section, the essential minerals are microcline and oligoclase, which by the statistical method give an angle of

[1] This work was done by Mr. J. D. MacKenzie in 1914 as part of his preparation for the Master's Degree. His death in December last cut short a brilliant career and makes one feel that no record of his activities should be lost. The story of his heroic war record and the fine fight he made after fearful wounds to win back to life and work in his chosen field has yet to be told. CHARLES PALACHE.

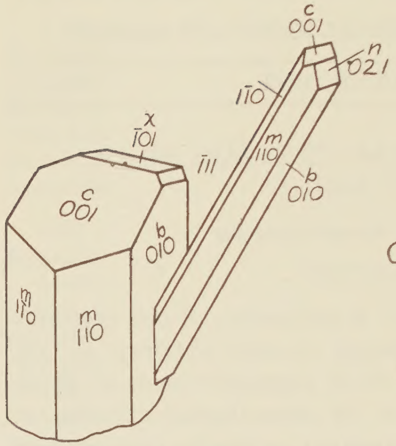

Fig. 1. Microcline. Perspective view.

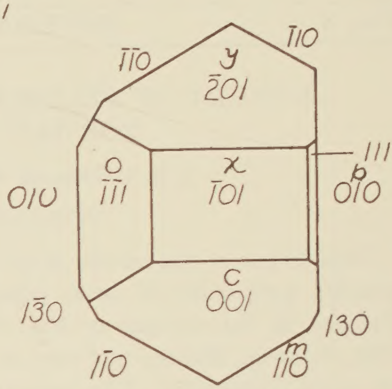

Fig. 2. Microcline. Plan.

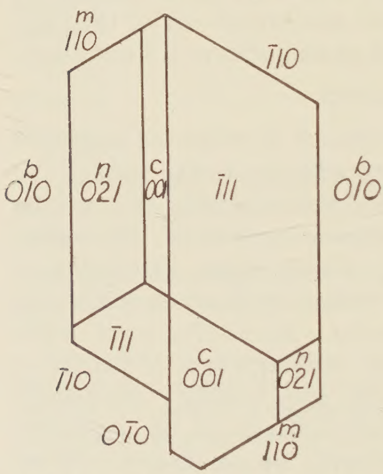

Fig. 3. Carlsbad twin of microcline. Plan.

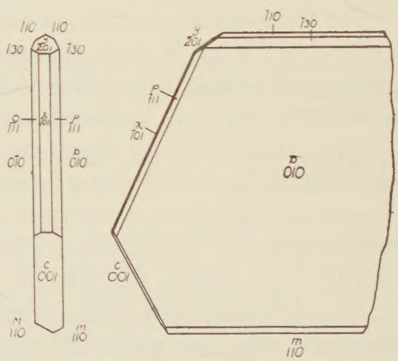

Fig. 4. Oligoclase. Left, plan; right, projection on 010.

extinction of 4° on the albite twinning in equally illuminated twins, corresponding to $Ab_{78}An_{22}$, with which the index of refraction (nearly equal to Canada balsam) and the optical character (negative), agree. Quartz is present also, and shows the wavy extinction caused by stress. Strongly pleochroic biotite and muscovite are subordinate minerals, while apatite and garnet are accessories.

THE PEGMATITE VEINS

Occurrence. All the feldspar, with the exception of the microcline illustrated in figures 11 and 12, came from a single vein. This vein is from 6 inches to 12 inches wide, and is exposed at the surface of the ground for about 100 yards. The specimens taken from it occurred at the surface, but in spite of this many crystals are remarkably glassy and quite unaltered. The contact of the vein with the granite is distinct, with no transition. The feldspar crystals are attached to the sides of the veins and project toward the center, which in the wider portions is composed of quartz molded on the sharply crystallized feldspar. Isolated feldspar crystals are found in this central quartz.

The microcline shown in figures 11 and 12 came from a nearby pegmatite, of which nothing further is known. These crystals measured about 4 by 5 by 6 inches, being thus much larger than the others studied.

Mineralogy. The minerals observed in the specimens of the pegmatite examined are, in order of abundance, oligoclase, microcline, quartz, muscovite and tourmaline. Brief notes on the minerals other than the feldspars are given here.

The quartz is grey and translucent, greatly crushed and sometimes having a platy fracture. It was the last mineral to cease crystallizing and has molded itself on all the others, in some instances filling cracks in them. The shattered nature of the quartz allows it to be readily broken from around the well-formed feldspar crystals.

The tourmaline is the common black variety, greatly cracked roughly parallel to the base, and re-cemented by quartz.

Muscovite occurs in crystals up to two inches across by three-fourths of an inch thick, and biotite is sparingly present in smaller crystals.

THE FELDSPARS

Both of the feldspars form exceptionally well crystallized individuals. Microcline and oligoclase are found in juxtaposition in groups of crystals, as well as separately crystallized.

Microcline. This mineral forms crystals up to two inches long, of a creamy white tint, and often with a somewhat pearly lustre not seen in the oligoclase. It is more generally altered than the oligoclase, and only rarely is glassy. On the whole, however,

the minerals are very similar in appearance, and frequently can be distinguished only with difficulty. Carlsbad twins are common. The following forms have been observed:

b (010)	*z* $(1\bar{3}0)$
c (001)	*x* $(\bar{1}01)$
m (110)	*y* $(\bar{2}01)$
M $(1\bar{1}0)$	*p* $(\bar{1}11)$
f (130)	*o* $(\bar{1}\bar{1}1)$
n (021)	

Typical crystals are illustrated in figures 1, 2 and 3. Figure 1 shows the usual short, stout variety, terminated principally by the large base and orthodome. The elongate form attached to the stout crystal in figure 1 is of rarer occurrence, and when found is usually in close relationship to the more equant variety, as illustrated. The elongate crystals are commonly Carlsbad twins. The crystal of figure 1 was broken in a number of places by fractures (not shown) virtually at right angles to the prism zone, and these were later healed by quartz. This breaking of the feldspar, often noted in other crystals, may have been concomitant with the shattering of the quartz.

The dimensions of the figured crystals are given in the following table.

	c axis	*b* axis	*a* axis
Figure 1 (a)	45 mm.	20 mm	30 mm
Figure 1 (b)	55	10	12
Figure 2	10	7	9
Figure 3	110	50	83

Basal thin sections of the microcline show a very fine, but highly developed grating structure.

The specific gravity, determined by weighing in distilled water at 20°C., is 2.566.

OLIGOCLASE: *Crystallography.*—The oligoclase crystals are usually white or creamy white, and often in part or wholly glassy and transparent, with a vitreous lustre. The individual crystals are polysynthetically twinned according to the albite law, the plates being in two unequal sets, the thinner ranging from 0.005 mm. to 0.1 mm., and the thicker from 0.02 mm. to 0.3 mm. thick. In addition, the oligoclase is frequently twinned after the Carlsbad, and also after the pericline law. A parting parallel to the latter twinning plane has been noted in some crystals.

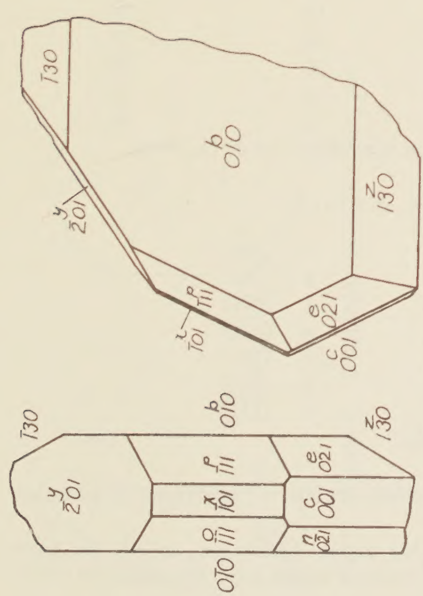

Fig. 5. Oligoclase. Left, plan; right, projection on 010.

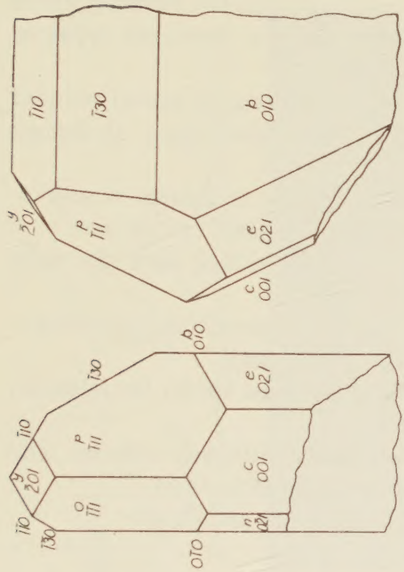

Fig. 6. Oligoclase. Left, plan; right, projection on 010.

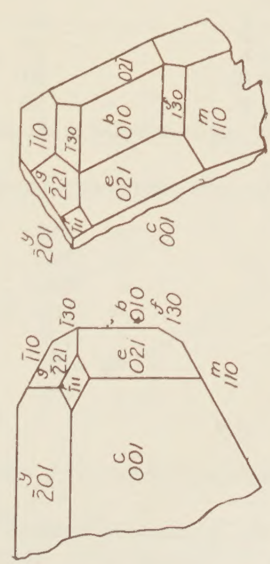

Fig. 7. Oligoclase. Left, plan; right, projection on 010.

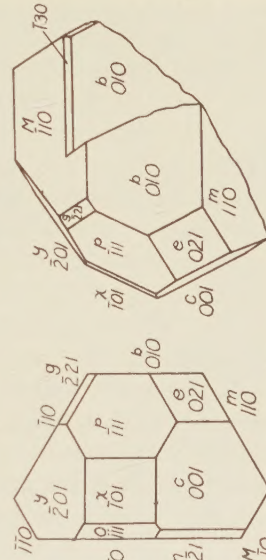

Fig. 8. Oligoclase. Left, plan; right, projection on 010.

Figure 12 is a photograph of a group of oligoclase crystals which illustrates their appearance. There are two principal types in which the oligoclase occurs, as follows:

(1) Equant, stubby crystals, (some of them elongate) pointed owing to the prominence of (021), $(\bar{1}11)$ and $(\bar{2}01)$, as figures 6, 10 and 11.

(2) Tabular, elongate parallel to (010) as figures 4 and 5.

Some noteworthy characters of the oligoclase crystals are:

(1) The prominence of the prism (130) rather than the more usual (110). Figures 4, 5 and 6.

(2) The constant and prominent development of the brachydomes (021) and $(0\bar{2}1)$, shown in all the crystals.

(3) The complex, well crystallized, unusual habits for feldspar, shown in figures 7 to 11.

(4) The occurrence of the markedly different tabular and stubby types in a single group of crystals. Figure 13.

The dimensions of the figured crystals are as follows:

	c axis	*b* axis	*a* axis
Figure 4.	20 mm.	2 mm.	20 mm.
Figure 5.	17	6	20
Figure 6.	35	15	35
Figure 7.	11	17	18
Figure 8.	38	18	32
Figure 9.	15	20	20
Figure 10.	30	12	20
Figure 11.	28	10	15

The largest oligoclase in the collection measures 65 by 60 by 60mm.

The following forms have been observed:[2]

a	(100)	*x*	$(\bar{1}01)$
b	(010)	*y*	$(\bar{2}01)$
c	(001)	*e*	(021)
m	(110)	*n*	$(0\bar{2}1)$
f	(130)	*p*	$(\bar{1}11)$
M	$(1\bar{1}0)$	*g*	$(\bar{2}21)$
z	$(1\bar{3}0)$	*o*	$(\bar{1}\bar{1}1)$

α $(1\bar{1}1)$

Optical Properties.—*Extinction angles.*—The extinction angles

[2] The crystals were measured with the contact goniometer, none of the faces being of reflecting quality. The zonal relations served to fix the character of the faces of more complex indices.

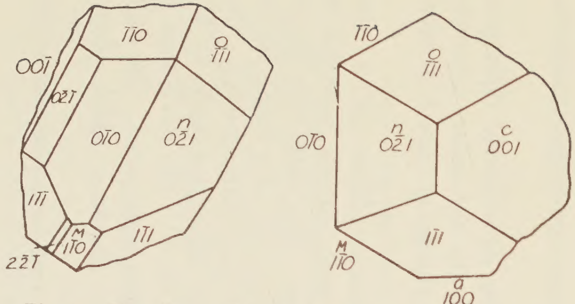

Fig. 9. Oligoclase. Left, projection on 0$\bar{1}$0; right, plan.

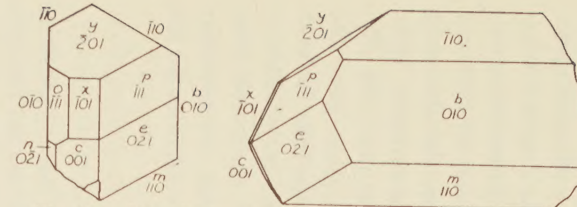

Fig. 10. Oligoclase. Left, plan; right, projection on 010.

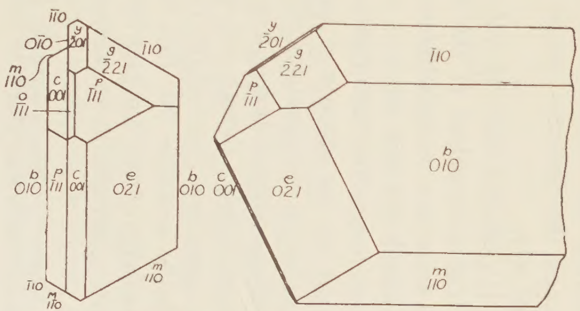

Fig. 11. Oligoclase. Carlsbad twin. Left, plan; right, projection on 010.

Fig. 12. Groups of oligoclase crystals illustrating the association of thin-tabular and equant stubby individuals.

of the oligoclase were measured on cleavage flakes obtained by crushing the feldspar to pass a 40 and remain on a 60 mesh sieve.

Extinction on 001 Cleavage Flakes.—The crushed fragments showing albite twinning did not afford satisfactory measurements, as the two sets of twinning lamellae were of different widths, one being constantly wider than the other, the difference being usually from 5 to 15 times the width of the narrower twin. The lamellae were not always straight, which also caused difficulty.

A thin section made from a basal cleavage plate gave the following values, which are the mean of ten readings in each position. The sensitive tint was used to determine the position of extinction of the lamellae, and the angles were measured from the trace of the 010 cleavage. The values given are probably correct within ten minutes for the first, and fifteen minutes for the second.

(1) Extinction angle of wider lamellae = 2°43′
(2) " " " narrower " = 1°00′

The first value corresponds very nearly to the composition $Ab_{85}An_{15}$,[3] and the second to $Ab_{75}An_{25}$. It is, of course, not considered that this apparent discrepancy in composition of the two sets of lamellae exists; rather is it explained by the difficulty of measuring the extinction accurately on the narrower bands, although the difference seems larger than can be accounted for in this way.

It is probable that the value $Ab_{85}An_{15}$ more nearly represents the true composition of the oligoclase, for the values obtained from extinction on the 010 face and the indices of refraction agree fairly well with this one.

Extinction on 010 Cleavage Flakes.—These flakes, recognized by the absence of twinning, were sharply bounded on two sides by the excellent 001 cleavage. The extinction angles in various flakes obtained from a small portion of a single crystal showed closely, though not absolutely accordant results. One flake gave as a mean of ten readings the extinction angle 10°47′, probably accurate (for this flake) within 5′. No deviations in other flakes of over a degree from this value were noted. The angle 10°47′ corresponds to a composition $Ab_{83}An_{17}$, which checks

[3] Schuster's values as given by Johannsen, Rock-forming Minerals in Thin Section, Wiley & Sons, *New York*, N. Y., 1908, p. 79.

fairly well with $Ab_{85}An_{15}$, obtained from a measurement on the wider lamellae in a basal section.

Optical Character.—The optical character of the oligoclase has been determined as negative.

Indices of Refraction.—Indices of refraction were measured by immersing cleavage flakes in liquids whose indices were known, and comparing the refraction of the flakes with that of the liquid. In this way, n_γ was found to be somewhat less than 1.554, and n_α about equal to 1.542. These values correspond to an oligoclase slightly more basic than the extinction angles indicate.

Specific Gravity.—The specific gravity of the oligoclase, determined by weighing in distilled water at 20°C, is 2.631. This agrees with the optical determinations of the high albite content of the mineral.

Remarks.—While the various results of determining the composition of the feldspar as detailed above agree fairly well among themselves, they are not as strictly accordant as one would ordinarily expect when it is considered that the measurements were made on orientated sections of very fresh material. When under these favorable conditions such discrepancies arise, the need of caution in stating the composition of feldspar as determined by optical tests on unorientated crystals in a thin section is apparent.

THE COLORING OF THE DIAMOND BY RADIUM RADIATION*

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The results of various investigators attempting to color the diamond by radium radiation have not been entirely uniform and in the main were unsuccessful. Doelter[1] classes diamond as the most difficult of all minerals to color, and reports for the most part failures or very slight coloring. On the other hand,

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[1] C. Doelter, "Das Radium und die Farben," Steinkopff, Dresden, 1910, p. 123.

Crookes[2] obtained in a few cases bluish-green and sage-green colors and A. Miethe[3] produced a yellow color from a colorless diamond in one instance.

As reported in the preceding paper,[4] all minerals except diamond, that can be colored by radium radiation, are colored by the penetrating (beta and gamma) rays transmitted through the glass tube containing the radium salt. Experiments of this character, using 250 mgs. Ra for thirty days on five Cape diamonds of four to ten carats of bright straw-yellow color, failed in all cases to produce any change in color. Two other cut diamonds of the same color were sealed inside a tube with 10 per cent. $RaCl_2$ for the same length of time. The one which was entirely covered by the 10 per cent. salt became fairly green (about a half grass-green) in thirty days, while the other, lying on the surface of the salt, took on a distinct but fainter green.

It was therefore quite evident that direct (probably alpha) radiation is necessary to color the diamond. This experiment explains why most investigators, working with penetrating radiation only, have failed to produce color changes.[5] To confirm this, four straw-yellow Cape cut diamonds of two to six carats were completely covered with 10 per cent. Ra Cl_2, sealed in a glass tube, and left for seventy-five days. A deep grass or sage-green was produced which was of quite uniform shade in all, and as far as could be detected, seemed to penetrate through the crystal. No trace of the yellow color appeared to remain.

The apparently deep penetration of color is very surprising, since alpha rays can penetrate diamond to a depth of the order of 0.001 inch only. This will be more fully discussed later. The non-penetrating character of alpha radiation also led to a second consideration, namely, that alpha rays will be able to reach the surface of the diamond only from those layers of salt immediately in contact with it (from a layer less than 0.001 inch). The rest of the salt absorbs its own alpha radiation and is wholly ineffective

[2] Sir Wm. Crookes, *Proc. Roy. Soc.*, 74, 47 (1904); *Nature*, 94, 300 (1914); *Phil. Trans. Roy. Soc.*, 214A, 433-45 (1914); *Sci. Amer. Supplement*, No. 2270 (July 5, 1919).

[3] A. Miethe, *Ann. d. Phys.*, 19, 633 (1906).

[4] *Jour. Frank. Inst.*, September, 1923, p. 375. Also *Am. Min.*, 8, p. 171.

[5] Crookes (*loc. cit.*), who obtained positive results, worked with the direct radiation of radium salts.

in producing any color changes. This suggested that radium emanation could be much more effectively employed, since at low gas pressure, the absorption in a container not too large will be practically negligible, and the proportion of effective radiation will depend principally upon the ratio: $\frac{\text{area of diamonds exposed}}{\text{total area exposed}}$.

Accordingly seven cut diamonds from 1.5 to 9.5 carats, of original color white to yellow, were sealed in a glass tube (about 10 cms. long and 1.5 cms. in diameter) with 114 millicuries (m.c.) initial radium emanation. The fluorescence was marked in all cases but not uniform, varying through greenish-blue to bluish-green shades without reference to the original color of the stones, which were supposed to represent one Brazilian and all the principal South African fields.[6] That the intensity of radiation was greater than in 10 per cent. salt was evident from the increased rate of coloring, though this cannot be accurately judged owing to the rapid coloring of the glass tube container. After an exposure of nine days, during which time 91.4 m.c. of emanation disintegrated, the tube was opened and all seven were found to be colored a moderate shade of green. They were put into another tube of the same dimensions and exposed for nine days to an initial quantity of 161 m.c. of emanation. At the end of this time all had deepened in green shade and were nearly as deep as the ones exposed for seventy-five days to 10 per cent $RaCl_2$. A third exposure was begun, but was continued for only a few hours, owing to the cracking of the glass tube. Upon examining some of the diamonds visually it was observed that they had apparently developed "carbon spots."[7] This was very puzzling, as "carbon spots" have never been reported as being produced artificially. The original crystals had been perfect, nor had any "carbon spots" been produced in the four diamonds colored to a deeper shade of green by 10 per cent. $RaCl_2$. Attempts to remove the spots chemically by washing in ammonia, hot HNO_3, hot chromic mixture, organic solvents, etc., failed. Examination under the high-power microscope revealed round black spots like fly specks at a considerable depth below the surface (as much as 1 to 2 mm.), a few of which

[6] Since all the diamonds examined had passed through commercial channels their origin cannot be given with certainty.

[7] Small specks of carbon, possibly graphite, which frequently are found in natural diamonds.

were surrounded by lighter brown halos as if the "carbonization" process were spreading from a centre.

The rest of the investigation was devoted to an attempt to solve the puzzling problems presented by the coloring and the "carbon spots," in connection with the nature of the latter, and the production of both at depths beyond the range of alpha particles in the diamond.

The coloring itself can be described in a few words. In five specimens of light-yellow cut diamonds no color by penetrating rays (through glass ½ to 1 mm. thick) could be produced in thirty days, as already stated. In more than thirty specimens of cut and one uncut diamond varying in color from colorless to yellow to brown, no failure to produce color by direct contact with radium salt or radium emanation was encountered. Green and only green color was produced; even the shade was the same for the same radiation intensity and the same original color. Prolonged heating to 500° C. restores the *original* color, leaving one to suppose that the green color is superimposed and merely masks the original color.

An estimation of the initial alpha radiation from emanation received per unit surface of diamond, in the experiment where "carbon spots" were first obtained, indicated that the alpha ray intensity was about five-fold that in the case of diamonds buried in 10 per cent. $RaCl_2$, when no spots were developed. Assuming that intensity is the controlling factor, exposure in 50 per cent. $RaCl_2$ ought to produce "carbon spots" also. A test was made with four Cape cut diamonds of about two carats each (three white and one slightly yellow) buried in 50 per cent. $RaCl_2$ for seventy-four days. A very deep grass or emerald green color was produced, practically identical in shade in all cases, but no "carbon spots" were produced. In all later experiments it was found that "carbon spots" are produced only in contact with emanation, never in salt, but not universally even in emanation, nor could we determine the factor which controls the carbonization. It was apparently not a characteristic inherent in the individual diamonds, because there were no variations among different specimens under the same conditions; either all or none developed "carbon spots" in a given test. One light yellow cut diamond of eight carats, which developed "carbon spots" in emanation and from

which they had been removed (see later), failed to develop any on being radiated with 50 per cent. $RaCl_2$ till it again colored green.

The nature of the spots also remained unsolved. It appeared plausible to suppose that under radiation, diamond, which is known to be an unstable form of carbon at ordinary temperature and pressure, should revert to the stable form graphite, just as white phosphorus has been shown to be converted to red by radium radiation.[8] That such a process might be taking place appeared probable from the brown halos surrounding a few of the spots. To explain the localization of discrete spots, rather than a general darkening similar to that observed by Crookes[9] under cathode-ray bombardment, it appeared plausible to suppose that there exist initial "seeding centres" where the change originates and from which it spreads. This theory was greatly shaken if not entirely upset by the observation that prolonged heating in air at a red glow caused the "carbon spots" to disappear permanently. We can hardly assume a reversion to diamond under these experimental conditions. We cannot attribute it to oxidation unless we assume the diffusion of oxygen into and possibly the diffusion of CO_2 or CO out of the diamond. A very ingenious hypothesis was proposed by Dr. R. B. Moore, namely, that there may be in the diamond minute pockets of CO_2 or CO under high pressure, not detectable by the microscope, which may be decomposed by the radiation into C and O_2 which recombine *in loco* upon heating. CO is the more probable, since CO_2 is very slightly decomposed, even by intense alpha radiation.[10] The depth of the pockets from the surface also imposes a difficulty since they cannot be reached by alpha rays, and beta and gamma rays are much less effective in producing chemical action. This theory also does not conform with the idea of gradual growth (brown halos); some of the spots become large enough to be visible to the naked eye, and all of them are easily visible with a small hand lens. That the spots are in reality some form of carbon is supported by the fact that the simultaneous exposure in emanation of a large number of different transparent minerals, together with the diamond, gave these spots only in the latter.

A most puzzling question is the explanation of any effect,

[8] H. Becquerel, *Comp. rend.*, **133**, 709-12 (1901).

[9] Sir Wm. Crookes, *Sci. Amer. Supplement*, **No. 2270** (1919).

[10] E. E. Wourtzel, *Le Radium*, **11**, 346 (1919).

either production of color or of "carbon spots," at a depth in the crystal exceeding the range of alpha rays—if one is to suppose the effect due to alpha rays. The question may be divided into two: (1) Are we sure that the effects are deeper than the alpha ray range? (2) Are they due to alpha rays? (1) There can be no doubt about the depth of the carbon spots below the surface, which were observed by the microscope (change of focus) and confirmed by the diamond-cutter who stated it would be necessary to cut away one-half to two-thirds of the crystals (of several carats) to remove the spots. In regard to the depth of penetration of *color* there is much doubt, and that point will therefore be referred to again. Question (2) can best be considered generally for either effect as follows:

The possibilities of the production of effects beyond the range of alpha rays appear to be the following: (*a*) By penetrating (beta or gamma) rays; (*b*) by soft beta rays which could not penetrate the wall of the glass container, but which do penetrate diamond sufficiently to produce the effects observed; (*c*) by a secondary penetrating radiation set up at the diamond surface by some form of non-penetrating radiation (including alpha rays); (*d*) by transmission by an electronic or atomic "chain effect" of a disturbance set up at the surface, possibly equivalent to (*c*); (*e*) (applying to color only) by the diffusion through the crystal of color produced at the surface. Hypothesis (*a*) can apparently be dismissed by comparing the negative results of exposure outside a tube with the positive ones inside. The possibility of (*b*) is not excluded, but it should be remembered that such soft radiation could not extend the depth beyond a layer equivalent to ½ to 1 mm. of glass, which would be insufficient to penetrate the entire crystal in the case of large diamonds. Regarding (*c*), no such form of radiation in diamond is known, nor would the low atomic weight of carbon indicate that it would have much penetration; on the other hand, not much would be required, for the same reason. Both (*d*) and (*e*) appear intangible at present. None of these hypotheses receives any support from the observations of Joly[11] and of Rutherford[12] on pleochroic halos in mica,

[11] J. Joly, "Radioactivity and Geology" (1909), pp. 64-9; *Phil. Mag.* (6), **19**, 327 (1910).

[12] E. E. Rutherford, "Radioactive Substances and Their Radiation" (**1913**), p. 310.

which have been shown to have exactly the diameter predicted by the range of alpha rays emitted from a point source, and which have persisted through geological periods of time.

We are therefore forced to leave the question of the penetration of the effects unsettled in regard to "carbon spots" and will conclude the discussion with the observations contained in the following paragraphs on the penetration of color.

As far as can be determined optically (even by gem experts), either with the unaided eye or with the microscope, the color produced in diamonds persists throughout the crystal. On the other hand, this is not consistent with a direct alpha-ray effect, though rigidly it does not need to be, since "carbon spots" are produced by some influence beyond the alpha-ray range and possibly color also. But color production is a much more general phenomenon than that of carbonization and need not be produced by the same radiation. Crookes (*loc. cit.*) found that the removal of the surface from a cut diamond destroys the color. This would appear to show that it is a surface coloring only, but it must be remembered that cutting or grinding a substance of such hardness is a prolonged process involving the generation of much heat, so that the destruction of color may be due to a heat effect.[13]

Two attempts were made to solve the question without cutting or grinding. A small brown cut diamond was colored green by radiation and then broken into two or three fragments. Examination under a high-power microscope failed to reveal any surface zone of color; each fragment with a colored (polished) surface appeared to be colored throughout, but the reflection and diffraction of green light from the polished (green colored) surfaces was so great that one could not be sure that the appearance of internal color was not merely due to an optical effect. The masking of an internal yellow or brown by green seems to demand more than a thin surface layer of green, but again one must recall that this thin green layer is produced at polished surfaces from which light is reflected in all directions, and also that the masking is *not* complete in *thick brown* crystals. An uncut chip of colorless

[13] It is interesting in this connection that in 1915, F. P. Mennell (*Mineralogical Magazine*, **17**, 202) described the occurrence of natural green diamonds in an alluvial field situated on the borders of the Somabula Forest in Southern Rhodesia. He states that the color is entirely lost in the usual course of cutting and polishing for use in jewelry.

diamond was colored green by radiation and then cleaved into two pieces. Viewed through the cleavage plane, the fragment still looked green, but again one could not be sure it was not due to reflection. The question might be settled by covering all the facets but one with foil or paint during radiation, and later covering the colored surface with an opaque covering and looking through the others. This experiment was not attempted.

The question of the color penetration remains unsettled with some evidence in favor of non-penetration, which, however, is not conclusive.

The question of the permanency of the green color to light is a much simpler one. Experiments, both in diffused and direct sunlight, showed that the color is quite permanent, perhaps in the same class with glass colored by radiation, though the observations have not yet extended over so long a period as with glass. This confirms the general rule already stated, that the more difficult a mineral is to color the more permanent the color. As stated, the color can be removed by heating to 500° or higher for half an hour or less (depending on the temperature). In this way green color can be toned down in shade by interrupting the heating at the desired point.

The question of imparting permanent radioactivity to the diamond by radiation by radium, which was the subject of experiments by Sir Wm. Crookes (*loc. cit.*), has not been investigated in the present work, but there seems to be no reason to believe this cannot be explained by "active deposit" (or radium itself in case of contact with radium salt), in the light of adsorption and surface phenomena as now explained by Langmuir and others.

Summary

1. Diamond is not colored by the penetrating (beta and gamma) radiation from radium salt in glass tubes 0.5 to 1 mm. thick.

2. Diamond is always colored green by direct radiation, either from high-grade radium salts or from the gas, radium emanation. No exceptions were met in more than thirty specimens.

3. The green color is apparently light-permanent, but can be removed by heating to a dull red.

4. Yellow and brown diamonds are also colored green, but are restored by heating to their original colors. In the case of

large deep brown stones the color masking by green was not complete.

5. Recutting the crystal after coloring removes the green color. This is possibly a heat effect during cutting, and does not prove that the coloring is merely a surface effect.

6. The depth of penetration of the color zone could not be determined. If it is an alpha-ray effect, it would be limited by the range of alpha rays in diamond, about 0.001 inch. But reflection of green light from the highly polished surface interferes with optical observations.

7. Radiation by emanation is more effective than by salts, owing to the greater absorption of alpha rays by the salt itself.

8. In some cases in emanation, but never in salt, the radiation resulted in the production of "carbon spots" in the interior of the crystal. The black spots are probably a form of carbon, the nature of which was not definitely determined. They can be removed by prolonged heating in a blast flame.

9. The "carbon spots" are undoubtedly beyond the range of alpha rays in the crystals, which suggests that the color may be penetrating also and that both are produced by some form of secondary radiation more penetrating than alpha rays.

NOTES AND NEWS

MINERAGRAPHIC NOTES ON MANGANESE MINERALS. Ernest E. Fairbanks. *Somerville, Mass.*

Coronadite from the Coronado vein, Clifton, Graham County, Arizona, was examined in polished section and found to consist of a mixture of hollandite (psilomelane) and an unidentified lead mineral. Lindgren,[1] who first described coronadite, shows that it consists chiefly of lead and manganese oxides.

A polished section gave the following results: galena white, very brittle mineral with a hardness of about 5.5 and with a brown streak. Throughout this mineral there is a finely disseminated substance which shows polarization with crossed nicols.

Following are the microchemical tests made on the surface containing the two minerals:

HNO_3—Fumes tarnish slightly, otherwise negative.

HCl—Fumes tarnish slightly, also faint tarnish produced which is not persistent.

KCN—Negative.

$FeCl_3$—Tarnishes brown, rubs lighter, and is fairly persistent.

[1] Lindgren, Waldemar; Copper deposits of the Clifton-Morenci district, Arizona, *U. S. G. S. Prof. Paper* 43, (1904) pp. 103-6.

KOH—Negative.

$HgCl_2$—Negative.

Aqua Regia—Tarnishes faintly, not persistent.

The disseminated constituent remained negative to all reagents.

Romanechite from the mines of Romaneche, Saone et Loire, France, was also examined in polished section and found to be a mixture. Lacroix[2] in describing romanechite showed that barium is present in notable amount in addition to manganese.

The polished section gave similar results to that of coronadite; it too consists of hollandite with an unidentified disseminated mineral.

Hollandite from Ihabua State, Central India, was found to be similar to the two minerals described in a polished section with the exception of the test with $FeCl_3$ which in this case gave a negative reaction. Remembering the lead content of coronadite, a drop of $FeCl_3$ containing lead was added and a tarnish was developed. This action may well be the "secondary electrolytic effect" of Schneiderhöhn.[3]

Hollandite is identical with psilomelane in composition, but crystallizes in the pyramidal group of the tetragonal system.

CELEBRATION OF THE 70TH BIRTHDAY OF PROFESSOR VICTOR GOLDSCHMIDT.[1] On the morning of Saturday, February 10, 1923, a group of close friends proceeded to Professor Goldschmidt's residence in Heidelberg. Geheimrat Salomon extended to him birthday greetings and good wishes, presented a volume containing the signatures of numerous friends, and expressed the hope that he would have many more enjoyable and fruitful years.

Professor Goldschmidt thanked him warmly, and expressed himself as especially pleased by the friendship and good will shown by the gift. It might be a misfortune, he said, for anyone to celebrate his 70th birthday, but he still felt young, and had never thought of bringing his work to a close; on the contrary, what had been done thus far was only preliminary, and the really fruitful years were yet to come. The Rector of the University and the Dean of the Faculty then appeared, and added their congratulations.

That evening over a hundred friends and well-wishers of the family assembled in the great hall of the Schwarzen Schiff Inn at Neuenheim, to pass the evening with Professor and Frau Goldschmidt. Professor Philipp of Greifswald spoke first of the masterly way in which Professor Goldschmidt commanded his Science, fashioning it really into an Art. Doctor Neff, in turn, referred to Professor Goldschmidt's genial and engaging personality. Finally Professor Goldschmidt himself spoke, first bringing to mind all his friends prevented by various circumstances from coming to Heidelberg, including those in foreign lands, especially in America, who were present in thought. He mentioned many friends by name, relating the

[2] Lacroix, A., Mineralogie de la France et de ses colonies, Vol. 4, 1910, pp. 6-12.

[3] Schneiderhöhn, Hans: The microscopic examination of opaque minerals in incident light and its significance toward the science of mineralogy and ore deposits, *Neues Jahrb.*, Supplement, vol. 43, 1920, p. 418.

[1] Abbreviated translation of a mimeographed account of the celebrations prepared by Dr. Oscar Neff, made by F. Bascom and Edgar T. Wherry.

memories which bound them to him. He then recalled old Freiberg days, how teaching was carried on there, and how he himself used that method as a model. Heidelberg and Freiberg are places of related traditions, where one could gather and hold a circle of friends, such as he now saw around him.

On Sunday morning, February 11th, the Portheim Stiftung, under the leadership of Professor Pfeiffer, held a jubilee meeting in the splendidly decorated hall of the Weimar House. It was the first time that this organization had sent out invitations to a wide circle of guests, and the hall was well filled. After a musical prelude, Professor Pfeiffer greeted the assemblage, and especially Professor Goldschmidt. The latter then spoke at length of the history, purposes and aims of the foundation. It possesses a number of buildings, mostly in Heidelberg, where scientific institutes are to be established. Several, including Professor Goldschmidt's own Crystallographic-Mineralogic Institute, are already in operation. He was particularly fond of the Institute for Investigation of Musical Theory, and gave an account of its progress, with musical illustrations, which interested the assembly greatly. A group of seven young girls dressed to represent the fundamental colors then appeared, and after discussing their respective values, finally grouped themselves so as to produce the maximum harmony; this idea had been originated, and the words composed, by Frau Goldschmidt. As a birthday gift the Portheim Stiftung presented a handsome leather bound volume containing an account of its history and a series of works from its new Institutes. Likewise the Winter publishing house made Professor Goldschmidt happy by the issue of a new volume of the Beiträge zur Krystallographie und Mineralogie, announcing, in addition, that the Atlas der Krystallformen is nearly completed.

That afternoon a supplemental celebration was held at Professor Goldschmidt's house; and eight days later many guests came there again, in honor of the birthday of Frau Goldschmidt.

ABSTRACTS: MINERALOGY

NOTE ON THE RIEBECKITE OF EVISA, CORSICA, AND ON THE COMPOSITION OF SIMILAR SODIC AMPHIBOLES FROM OTHER LOCALITIES. J. ORCEL. *Bull. soc. franc. min.*, **43**, 232-243, 1920.

Analysis of riebeckite from pegmatite in a riebeckite granite from near Evisa shows approx. $8SiO_2.3FeO.Fe_2O_3.2Na_2O.H_2O$. Sp. gr. 3.40. E. F. H.

NOTE ON BRANNERITE. ROGER C. WELLS. *J. Franklin Inst.*, **189**, 779-80, 1920.

Helium was spectroscopically identified in the gas evolved by fusing brannerite with Na bisulfate. (See *Am. Min.*, **5**, 105.) E. F. H.

SILICEOUS SINTER FROM LUSTLEIGH, DEVON. A. B. EDGE. *Mineral. Mag.*, **19**, [88] 10-13, 1920.

The material is hard and compact, either white or banded in various shades of red depending upon the amount of hematite included. In some instances the layers are folded and the material appears to have been deposited as a siliceous jelly which has hardened by loss of water. An analysis showed about 70% SiO_2 and 21% of H_2O. W. F. H.

THE FRENCH ECLOGITES, THEIR MINERALOGIC AND CHEMICAL COMPOSITION, AND ORIGIN. Y. Brière. *Bull. soc. franc. min.*, **43**, 72-222, 1920.

Contains a description of the pyroxene omphacite, an essential constituent of eclogites. It is green, colorless in thin sections, sometimes slightly pleochroic, plane of optic axes parallel to (010), $Z_\wedge c = 36°$, sign +, $2E = 140°$, sp. gr. 3.31. Analysis shows it to be high in alumina and soda, hence it may be called a jadeitic augite.

E. F. H.

A NEW APERTOMETER. E. A. Wülfing. *Sitzungsber. Heidelberger Akad. Wiss., Math.-naturw. Kl.*, **1917**, Abt. A, Abh. 2, 13 pp; thru *Mineralog. Abstr.*, **1**, 363.

The optic axial angle of an unknown substance or the numerical aperture of a microscope may be determined by using thin cleavage plates of mica, of such good quality that their interference figure in monochromatic convergent light is constant over the entire plate. The method of preparing such plates is given. E. F. H.

NUMERICAL APERTURE AND THE ANGLE OF THE OPTIC AXES. E. A. Wülfing. *Sitzungsber. Heidelberger Akad. Wiss., Math.-naturw. Kl.* **1919**, Abt. A, Abh. 5, 18pp; thru *Mineralog. Abstr.*, **1**, 363.

The values of β, V, and of the numerical aperture $\beta \sin V$ of biaxial rock forming minerals are tabulated. A diagram is given for the graphical solution of the equation $U = \beta \sin V$ when two of the quantities U, V, β are given. E. F. H.

INVESTIGATION OF HALITE FOR PYROELECTRICITY. V. Posejpal. *Beitr. Kryst. Min.*, **1**, 257-60, 1918; thru *Mineralog. Abstr.*, **1**, 423.

Careful tests for pyroelectricity on halite, made with a delicate electrometer, gave negative results. E. F. H.

ON THE BASALTS OF THE "BLAUE KUPPE BEI ESCHWEGE" AND ADJACENT OCCURRENCES, AND THEIR CRISTOBALITE. Paul Ramdohr. *Centr. Min.*, **1920**, 33-36.

The basalt is fine grained and composed of olivine, augite, plag. feldsp., ores, apatite, a little biotite and hornblende. At the contact with the sandstone the blocks of the latter that have become engulfed in the basalt have been altered with the formation of new minerals, as cordierite, orth. and monocl. pyroxene, ores and feldspar. Pneumatolytic minerals are magnetite, specular hematite, cristobalite, tridymite, chalcedony, apatite, hypersthene, augite, feldspar, mica and titanite. Crystals of cristobalite are generally smaller than 1 mm., milky white, and occur in three habits. All become isotropic at 235-250°C. D. = 2.290-2.320; $n = 1.485$; birefringence = .0018. Interpenetration twins also occur and are shown to be due to distortion of different octahedral faces of two octahedrons in parallel position.

Otto von Schlichten.

MINERALS AND ORES FROM SOUTH WEST AFRICA, ESPECIALLY FROM TSUMEB. O. Pufahl. *Centr. Mineral.*, **1920**, 289-96.

See *Amer. Mineral.*, **6**, 140-1 (duftite). The following are described: Zn-rich tennantite, Zn 9.24-9.27%; mimetite (analysis); mottramite, two analyses, corrected mean: PbO 54.31, CuO 19.24, ZnO 0.18, MnO trace, V_2O_5 20.23, As_2O_5

2.16, H_2O 3.88, sp. gr. 5.9; cuprodescloizite, PbO 54.90, CuO 16.27, ZnO 3.51, Fe_2O_3 and MnO trace, V_2O_5 21.69, As_2O_5 1.36, H_2O 2.33, SiO_2 0.07, sum 100.13, sp. gr. 6.19. E. F. H.

SOME EXAMPLES OF "UNUSUAL" FELDSPAR TWINNING LAWS IN ALBITES OF THE GERMAN KERATOPHYRES. K. SCHLOSSMACHER. *Centr. Mineral.*, **1920**, 193-203.

Manebach, l'Esterel, and la Roc Tourne law twins were found in these rocks, as well as the more common types. E. F. H.

SOME USES AND EXTENSIONS OF THE IMBEDDING METHOD. K. SPANGENBERG. *Centr. Mineral.*, **1920**, 352-62, 406-14.

The following are discussed: (1) Quantitative det'ns by measurements on two boundaries of anisotropic grains. (2) Det'n of plagioclase by means of refractive index and the Becke method, using feldspar-quartz, f.-nephelite, and f.-balsam boundaries. (3) Det'n of the position of the plagioclase sections from the twinning lamellae. (4) Det'n of the indices of spherulites. (5) Absolute det'n of refraction by measurements on several boundaries. E. F. H.

THE OCCURRENCE OF ZINC BLENDE IN BASALT FROM BÜHL NEAR CASSEL. W. EITEL. *Centr. Mineral.*, **1920**, 273-85.

Inclusions of sphalerite were identified in this basalt. With it are quartz, pyrrhotite and some pyrite. The pyrite was disassociated to pyrrhotite, and some FeS went into solid soln. with ZnS Two analyses of the ferriferous sphalerite are given: FeS: ZnS = 1:4 to 1:3. E. F. H.

THE MINERAL FACIES OF ROCKS. PENTTI ESKOLA. *Norsk Geologiske Tidsskrift*, **6**, 143-194, 1920.

An attempt to develop a natural classification of rocks, based on equilibrium relations of the minerals present. These minerals are termed critical when they are stable only in a given facies, and typical when they occur also in others. Rocks may contain unstable minerals, as relics of earlier stages in the crystallization of the magma, or as posterior (often inappropriately termed secondary). A rock of a given chemical composition may appear in any one of 5 facies, the critical minerals for each are respectively (starting with the surface conditions and ending with the most deeply seated ones): sanidine feldspar+clinoenstatite-diopside; hypersthene-diopside; chlorite-muscovite+epidote-albite; amphibole; and almandite-pyrope+jadeite-pyroxene. E. T. W.

INTERGROWTHS OF TOPAZ-GARNET AND RUTILE-HEMATITE. LAZARD CAHN. *Beitr. Kryst. Min.*, **2**, 7-9, 1919; thru *Mineralog. Absts.*, **1**, 343.

On garnet from Dugway, Utah a network of topaz needles in three sets were noted on each face of the tetragonal trisoctahedron. This regular grouping is very similar to that shown by rutile on hematite. E. F. H.

TOPAZ AND GARNET. V. GOLDSCHMIDT AND R. SCHRÖDER. *Beitr. Kryst. Min.*, **2**, 11-16, 1919; thru *Mineralog. Absts.*, **1**, 343.

(See preceding abstract.) The face *b* of topaz is parallel to *n* of the garnet;

on each n-face the topaz crystals of one of the three sets have their prism-zone parallel to the garnet zone *o n c*. Those of the other two sets are in twinned position with twin-planes *d*. E. F. H.

ITALITE, A NEW LEUCITE ROCK. Henry S. Washington. *Am. J. Sci.*, **50**, 33-47, 1920.

Melanite garnet from this rock (locality Rocca Monfina, near Naples, Italy) contained 8.7% TiO_2, $n=1.94$. Other new detns. are: melanite, Beaver Creek, Colo., TiO_2 5.08, n 1.95; schorlomite, Magnet Cove, Ark., $TiO_2=16.90$, $n=1.94$; ivaarite, Kuusamo, Finland, $TiO_2=18.98$, $n=2.01$; melanite, East Rock, Conn., TiO_2 none, $n=1.86$-1.88. E. F. H.

THE BINARY SYSTEM ÅKERMANNITE-GEHLENITE. J. B. Ferguson and A. F. Buddington. *Am. J. Sci.*, **50**, 131-40, 1920.

The binary system $2CaO.MgO.2SiO_2$ (åkermannite) and $2CaO.Al_2O_3.SiO_2$ (gehlenite) was studied by the quenching method, and found to form a complete series of solid solns. with a minimum melting point. The opt. properties are continuous functions of the composition. Pure gehlenite, $\omega=1.669$, $\epsilon=1.658$,—, elong. γ; åkermannite, $\omega=1.632+$, $\epsilon=1.639+$, +, elong. α. There is an intermediate isotropic compound. The densities also vary directly with the composition: gehlenite, xls. 3.038, glass 2.884; åkermannite, xls. 2.944, glass 2.955. E. F. H.

RUTILE FROM TRAVERSELLA. F. P. Müller. *Beitr. Kryst. Min.*, **1**, 159-65, 1919; thru *Mineralog. Absts.*, **1**, 344.

Rutile is abundant in glaucophane schists at Traversella, Piedmont. In quartz lenses are nests of large crystals (up to 8cm.). The faces are much striated, by secondary lamellar twinning on *e*(101). E. F. H.

REALGAR FROM JOACHIMSTAL (BOHEMIA). Fr. Büchler and V. Goldschmidt. *Beitr. Kryst. Min.*, **1**, 181, 1918; thru *Mineralog. Absts.*, **1**, 344.

One crystal showing ten forms is described. Realgar is not common here. E. F. H.

MINERALS NEW TO ONTARIO. *Ann. Rpt. Ont. Bur. Mines*, **28**, 90-5, 1919.

Elaterite. (C. W. Knight)—This mineral is found associated with barite, calcite and fluorite at Madoc. The origin is obscure.

Kalgoorlite; Coloradoite. (A. G. Burrows)—Rich gold ores from the Tough-Oakes mine, Kirkland Lake, contained gold, calaverite, altaite, and (new for Canada) kalgoorlite and coloradoite. Other tellurides which have been recognized in Ontario are tetradymite, petzite, and hessite.

A new discovery of Pitchblende. (C. W. Knight)—Pitchblende with $U_3O_8=74.98\%$ has been found in Butt township, east of Georgian Bay. It occurs in a pegmatite with feldspar, quartz, mica, tourmaline, and other minerals unidentified. E. F. H.